Design and Development of a Serious Game for Central Line Placement

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Abstract

Serious games are gaining popularity in being used for training purposes in various fields. They were first used for training various medical and military procedures. At present, there are several platforms available for developing serious games. In this paper, we present a serious game designed using a gaming engine called Unreal Engine, which facilitates the development of serious games for PCs as well as mobile iOS devices. The serious game that is presented in this paper is designed to provide training for the aseptic method for Central Venous Catheter (CVC), also known as central line, placement procedure. The pilot study was performed with first year residents from the department of anesthesiology at Mount Sinai Medical Center, NY and the residents claimed they felt it aided them in their line placements.

1. Introduction

A serious game is a type of video game, played with some specific rules, that focuses on providing training on education, health, public policy, and strategic communication [1]. Serious games facilitate learning in an immersive environment. Such environment is capable of setting clear goals for individual users and requires users to make frequent and important decisions throughout the training sessions [2]. Serious games were initially designed for aviation to train pilots under different circumstances. The approach of simulation based aviation training was later adopted by various other industries; most notable is healthcare education.

In recent years, different platforms have emerged for the development of highly immersive serious games: virtual worlds such as Second Life; and, gaming engines such as Unreal Engine and Unity. In this paper we present a serious game for central line or central venous catheter (CVC) placement procedure designed using Unreal Development Kit (UDK).

Annually five million CVCs are placed [3] and approximately 5% to 26% of them lead to complications [4]. Failure to follow the aseptic techniques properly during placement is one of the causes for the complications. The major focus of the game is to train residents on the aseptic method of CVC placement to help reduce the complication that might arise during the procedure. The major contributions of this study are:

- We have designed and developed a serious game for CVC procedure training using UDK.
- It can be played in both Windows® and iOS® platforms and can provide real-time feedback to users during practice sessions.
- It stores necessary information from the training/testing sessions in a remote database server to be later used for objective evaluation, summative feedback, and performance tracking.

2. Methodology

In this section, we present the design architecture of the system. The conceptual design of the CVC training simulator is presented in Figure 1.

2.1. CVC Game Development

The CVC game design consists of four major components: Game Interface, Database, CVC Algorithm & Scoring, and web-portal for registration and performance tracking.

2.1.1. Game Interface. The graphical user interface (GUI) of the simulator is designed using Unreal Development Kit (UDK). UDK is a game development toolset that is based on Unreal Engine 3. Complex graphical objects were first designed using MAYA® and then imported into UDK environment. The game environment, as shown in Figure (2), consists of heads-up display (HUD) and the gaming window. The top HUD is placed in order to provide formative (real-time) feedback to the users.
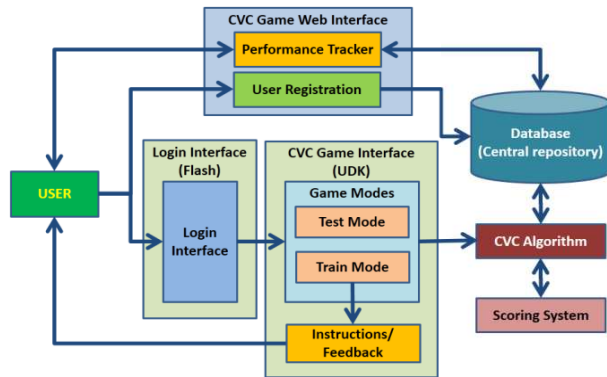
Figure 1. System design of the CVC game.

Figure 2. CVC game environment.

Users can track their performance in terms of time elapsed so far, current score, and overall progress during the training. The main gaming window consists of a virtual hospital room where a patient is lying on a stretcher; central line kit; and other objects such as wash basin, patient file holder, masks, and gloves are placed on the virtual walls.

2.1.2. Database component. The database component stores user information provided during registration (using web-portal) and their performance data during training or testing sessions in a central repository. We used C++ - MySQL® connector API for this purpose. The stored information is retrievable using the credentials that users create during registration.

2.1.3. CVC algorithm and scoring system. The CVC placement simulator has been designed by incorporating current best practices for CVC placement specified in the American Society of Anesthesiologists and the Institute for Healthcare Improvement Central Line Bundle. The back-end of the CVC game is an expert system that follows the CVC placement requirement checklist presented by Dong et. Al.[5].

2.2. CVC Game Simulation

Prior to the start of the CVC game, users are required to register themselves using unique user name and password at our web portal. Users have to use the same credentials to log in to the game. During the login process, users can select one of the two game modes: training and testing. In the training mode, a user is provided with instructions to follow the proper order of the steps and any interaction violating that order is not allowed. Additionally, instructions, alerts and time are shown during the training session. In this mode there is no penalty for time taken. However, the testing mode does not display any instructions, alerts, or time to the users. The scoring system checks the steps performed and the order in which they are performed, and awards points accordingly.

3. Game Roll Out

The game was initially released at Mount Sinai Medical Center, NY for residents in the department of anesthesiology. The participants were given access to the game and asked to provide feedback on their experience. Residents were given the option of choosing a platform for the game. The participating residents reported using the game once per month and claimed they felt it aided them in their line placements. Most residents preferred the iPad platform, and felt that the game not only enhanced their ability to place central lines, but that they could also perform the task safer than before and would feel more comfortable teaching others the technique.

4. Conclusion

In this paper, we presented a serious game intended to provide training on the procedural aspect of CVC placement. One of the major objectives of this pilot program is to make it ubiquitous. With the use of Internet and portable devices, this objective can be successfully realized. We hope to expand our program with a trial in the near future.

5. References

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